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BIOLOGICAL INTEGRITY OF THE EAST BOULDER RIVER BASED ON THE COMPOSITION AND STRUCTURE OF THE BENTHIC ALGAE COMMUNITY

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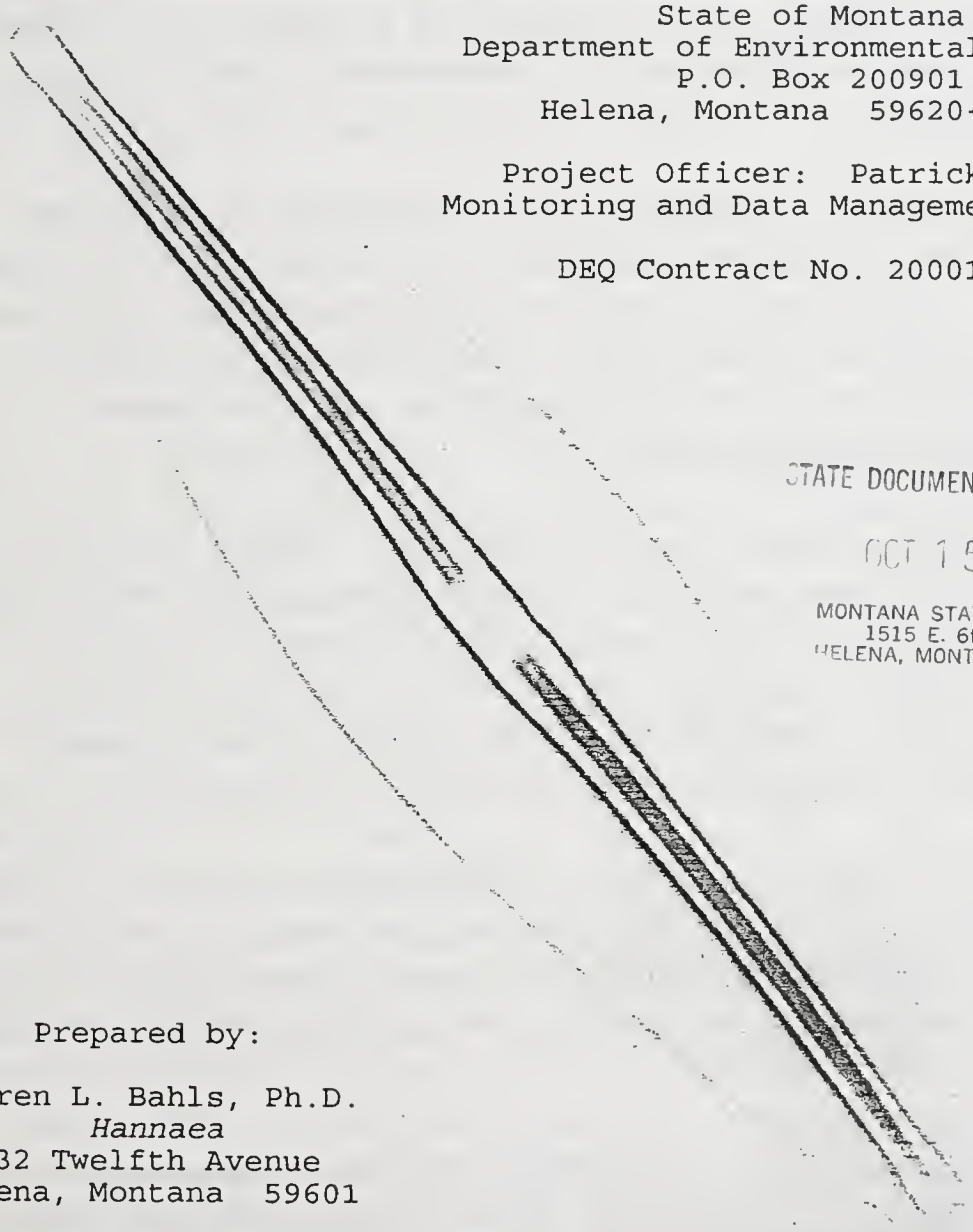

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SUMMARY

In 1998 and 1999, six composite periphyton samples were collected from five sites on the East Boulder River near Big Timber, Montana for the purpose of assessing whether this stream is water-quality limited and in need of TMDLs. The samples were collected following DEQ standard operating procedures, processed and analyzed using standard methods for periphyton, and evaluated following modified USEPA rapid bioassessment protocols for wadeable streams.

Attached algae indicated cold, nutrient-poor, and fast-flowing waters in the East Boulder River, especially at the upper two sites. An increase in the number of non-diatom algal genera and diatom species below Dry Fork Creek and below Elk Creek probably indicates an increase in biologically available nutrients below these tributaries.

Low diatom diversity and high percent dominant species indicated a moderate amount of stress at Stations 1 and 2, and minor stress at Stations 3 and 4. This stress is probably natural and caused by the cold, nutrient-poor, and rapidly-flowing waters at these sites. This natural stress represents the baseline condition for the upper East Boulder River.

Minor siltation was noted near the mouth at Station 5, and minor organic loading was indicated at Station 3 in 1999. Algae samples collected by University of Montana researchers in 1998 indicated moderate siltation and minor organic loading below Elk Creek and moderate siltation near the mouth of the East Boulder River. Otherwise, aside from indicators of natural stress, diatom metrics indicated excellent biological integrity, no impairment, and full support of aquatic life uses at all sites on the East Boulder River.

INTRODUCTION

This report evaluates the biological integrity, support of aquatic life uses, and probable causes of impairment to those uses in the East Boulder River, a tributary of the Boulder River in the Yellowstone River Basin of southcentral Montana. The purpose of this report is to provide information that will help the State of Montana determine whether the East Boulder River is water-quality limited and in need of TMDLs.

The federal Clean Water Act directs states to develop water pollution control plans (Total Maximum Daily Loads or TMDLs) that set limits on pollution loading to water-quality limited waters. Water-quality limited waters are lakes and stream segments that do not meet water-quality standards, that is, that do not fully support their beneficial uses. The Clean Water Act and USEPA regulations require each state to (1) identify waters that are water-quality limited, (2) prioritize and target waters for TMDLs, and (3) develop TMDL plans to attain and maintain water-quality standards for all water-quality limited waters.

Evaluation of use support in this report is based on the species composition and structure of the periphyton (benthic algae, phytobenthos) community at five sites that were sampled in 1998 and 1999. The periphyton community is a basic biological component of all aquatic ecosystems. Periphyton accounts for much of the primary production and biological diversity in Montana streams (Bahls et al. 1992).

Plafkin et al. (1989) and Stevenson and Bahls (1999) list several advantages of using periphyton in biological assessments:

- Algae are universally present in large numbers in all streams and unimpaired periphyton assemblages typically support a large number (>30) of species;

- Algae have rapid reproduction rates and short life cycles, making them useful indicators of short-term impacts;

- As primary producers, algae are most directly affected by physical and chemical factors, such as temperature, nutrients, dissolved salts, and toxins;

- Sampling is quick, easy and inexpensive, and causes minimal damage to resident biota and their habitat;

- Standard methods and criteria exist for evaluating the composition, structure, and biomass of algal associations;

- Identification to species is straightforward for the diatoms, for which there is a large body of taxonomic and ecological literature;

- Excessive algae growth in streams is often correctly perceived as a problem by the public.

- Periphyton and other biological communities reflect the *biological integrity*[1] of waterbodies; restoring and maintaining the biological integrity of waterbodies is a goal of the federal Clean Water Act;

- Periphyton and other biological communities integrate the effects of different stressors and provide a measure of their aggregate impact; and

- Periphyton and other biological communities may be the only practical means of evaluating impacts from non-point sources of pollution where specific ambient criteria do not exist (e.g., impacts that degrade habitat or increase nutrients).

Periphyton is a diverse assortment of simple photosynthetic organisms called algae, and other microorganisms that live attached to or in close proximity of the stream bottom. Most algae, such as the diatoms, are microscopic. Diatoms are distinguished by having a cell wall composed of opaline glass--hydrated amorphous silica. Diatoms often carpet a stream bottom with a slippery brown film.

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[1] *Biological integrity* is defined as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region" (Karr and Dudley 1981).

Some algae, such as the filamentous greens, are conspicuous and their excessive growth may be aesthetically displeasing, deplete dissolved oxygen, interfere with fishing and fish spawning, clog water filters and irrigation intakes, create tastes and odors in drinking water, and cause other problems.

PROJECT AREA AND SAMPLING SITES

The project area is located in Sweet Grass County in southcentral Montana. The East Boulder River heads on the East Boulder Plateau in the Absaroka-Beartooth Wilderness at an elevation of about 10,000 feet. The East Boulder River is a third-order tributary of the Boulder River, which is a tributary of the Yellowstone River.

The East Boulder River begins in the Middle Rockies Ecoregion and enters the Montana Valley and Foothill Prairies Ecoregion about midway through the study reach (Woods et al. 1999). The surface geology of the upper watershed consists of high-grade Precambrian metamorphic rocks of various lithologies (Renfro and Feray 1972). Vegetation is alpine tundra at the highest elevations, conifer forest at middle elevations, and grassland below the mouth of the East Boulder Canyon (USDA 1976).

Periphyton samples were collected at five sites on The East Boulder River in 1998 and 1999 (Maps 1 and 2, Table 1). The upper site above Dry Fork Creek is located at an elevation of about 6,300 feet. Elevation at the lowest site near the mouth of the river is about 5,000 feet. The East Boulder River is classified B-1 in the Montana Surface Water Quality Standards.

METHODS

Periphyton samples were collected by Patrick Newby of the MDEQ Monitoring and Data Management Bureau following standard operating procedures of the MDEQ Planning, Prevention, and Assistance Division.

Using appropriate tools, microalgae were scraped, brushed, or sucked from natural substrates in proportion to the rank of those substrates at the study site. Macroalgae were picked by hand in proportion to their abundance at the site. All collections of microalgae and macroalgae were pooled into a common container and preserved with Lugol's solution.

The samples were examined to estimate the relative abundance and rank by biovolume of diatoms and genera of soft (non-diatom) algae according to the method described in Bahls (1993). Soft algae were identified using Dillard (1999), Prescott (1978), Smith (1950), and Whitford and Schumacher (1984). These books also served as references on the ecology of the soft algae, along with Palmer (1977) and VanLandingham (1982).

After the identification of soft algae, the raw periphyton samples were cleaned of organic matter using sulfuric acid, and permanent diatom slides were prepared using Naphrax, a high refractive index mounting medium, following *Standard Methods for the Examination of Water and Wastewater* (APHA 1998). Between 225 and 429 diatom cells (450 to 858 valves) were counted at random and identified to species. The following were used as the main taxonomic and autecological references for the diatoms: Krammer and Lange-Bertalot 1986, 1988, 1991a, 1991b; Patrick and Reimer 1966, 1975. Lowe (1974) was also used as an ecological reference for the diatoms.

The diatom proportional counts were used to generate an

array of diatom association metrics (Table 2). A metric is a characteristic of the biota that changes in some predictable way with increased human influence (Barbour et al. 1999).

Metric values from the East Boulder River were compared to numeric biocriteria or threshold values developed for streams in the Rocky Mountain Ecoregions of Montana (Table 3). These criteria are based on metric values measured in least-impaired reference streams (Bahls et al. 1992) and on metric values measured in streams that are known to be impaired by various sources and causes of pollution (Bahls 1993).

The criteria in Table 3 distinguish among four levels of impairment and three levels of aquatic life use support: no impairment or only minor impairment (full support); moderate impairment (partial support); and severe impairment (nonsupport). These impairment levels correspond to excellent, good, fair, and poor *biological integrity*, respectively.

Quality Assurance. Several steps were taken to assure that the study results are accurate and reproducible.

Upon receipt of the samples, station and sample information were recorded in a laboratory notebook and the samples were assigned a unique number compatible with the Montana Diatom Database, e.g., 0836-04. The first part of this number (0836) designates the sampling site (East Boulder River near mouth); the second part of this number (04) designates the number of periphyton samples that have been collected at this site to date for which data have been entered into the Diatom Database.

Sample observations and analyses of soft (non-diatom) algae were recorded in a lab notebook along with station and sample information provided by MDEQ. A portion of the raw sample was used to make duplicate diatom slides. After completing the

diatom proportional count, the slide used for the count will be deposited in the University of Montana Herbarium in Missoula. The other slide will be retained by *Hannaea* in Helena.

On completion of the project, station information, sample information, and diatom proportional count data will be entered into the Montana Diatom Database.

RESULTS AND DISCUSSION

Results are presented in Tables 4 and 5, which are located near the end of this report following the Literature Cited section. Spreadsheets containing completed diatom proportional counts, with species' pollution tolerance classes (PTC) and percent abundances, are attached as Appendix A.

SAMPLE NOTES

East Boulder River Station 1. Very little sediment was present in this sample.

East Boulder River Station 2. Very little sediment was present in this sample.

East Boulder River Station 3 (1998). This sample was *very* sparse; only 225 diatom cells were counted in 10 transects across the coverslip. The sample contained very little sediment.

East Boulder River Station 3 (1999). This sample was dominated by a single colony of *Schizothrix*, which appeared as a dark green rubbery mat with a bumpy surface. Otherwise, this sample was sparse and the entire sample (except the *Schizothrix* colony) was processed to make diatom slides. Two species of *Phormidium* were present, one with wide filaments and the other

with narrow filaments. *Ulothrix* and *Stigeoclonium* appeared as short, unbranched filaments attached to the *Schizothrix* colony.

East Boulder River Station 4. This sample was also sparse and the entire sample was used to make diatom slides.

East Boulder River Station 5. A species of *Phormidium* with wide filaments occurred here. *Stigeoclonium* appeared as short, unbranched filaments. Two species of *Closterium* were present.

NON-DIATOM ALGAE

Diatoms and cyanobacteria were present in all samples from the East Boulder River (Table 4); green algae were present at all sites except Station 4. The combination of diatoms, green algae, and cyanobacteria is the usual complement of algae in mountain streams in Montana (Bahls et al. 1982). The pollution-sensitive red alga *Audouinella* was abundant at Station 2, rare at Station 3 (1998), and absent elsewhere.

The number of non-diatom algal genera ranged from 1 at Station 4 above Elk Creek to 7 at Station 2 below Dry Fork Creek. Mountain streams in western Montana normally support between 1 and 10 genera of non-diatom algae, with an average of 5 (Bahls 1993). The number of non-diatom genera tends to increase with increasing nutrient concentrations. This may help explain why the site below Dry Fork Creek supported the most genera.

Cyanobacteria accounted for most of the biomass at all sites except Station 1, where diatoms were dominant. *Phormidium* and *Oscillatoria* were the most abundant cyanobacteria at all sites except Station 3. These are closely related genera containing many species that exhibit a wide range of pollution tolerance (VanLandingham 1982).

At Station 3, the epiphyte *Chamaesiphon* dominated the flora in 1998 and rubbery dark-green colonial mats of *Schizothrix* dominated in 1999. Different species of *Chamaesiphon* tolerate a wide range of water quality conditions; most species of *Schizothrix* are saprophobic, meaning that they are restricted to very clean waters (VanLandingham 1982).

Three genera of filamentous green macroalgae were present in the East Boulder River samples, although none of these algae were abundant or conspicuous. *Chaetophora*, which is characteristic of cold, rapidly flowing streams, was common at Station 3 in 1998. *Ulothrix*, which also indicates cold, flowing waters, was frequent at Stations 1, 2 and 3 (1999 only). *Stigeoclonium*, which sometimes indicates nitrogen enrichment, was frequent at Station 3 in 1998 and common at Stations 1, 3 (in 1999) and 5.

DIATOMS

The major diatom species in the East Boulder River were either sensitive to pollution (Class 3) or only somewhat tolerant of pollution (Class 2). *Achnanthes minutissima* was the dominant diatom species in the upper East Boulder River, accounting for over 50% of the diatom cells at Stations 1 and 2 (Table 5). This is a pioneer "weed" species that colonizes recently disturbed substrates. In the East Boulder River, the disturbance registered by large numbers of this diatom is probably natural and due to physical scour caused by high current velocities. Percentages of *A. minutissima* approaching 70% have been recorded in pristine streams in western Montana (Bahls et al. 1982).

Cold, fast, nutrient-poor waters and large numbers of *Achnanthes minutissima* were also responsible for the very low species richness and species diversity values in the upper East Boulder River (Table 5). Rather than indicating minor to moderate impairment, the abundance of *A. minutissima* and the low

diversity and species richness values probably indicate natural stress and represent baseline conditions for the East Boulder River. As expected, the percent abundance of *A. minutissima* declined in a downstream direction. The number of diatom species nearly doubled from above to below Dry Fork Creek (Table 5), probably in response to an increase in nutrients.

The pollution index indicated excellent water quality at all sites except at Station 3 in 1999, where the pollution index dipped into the range of minor impairment. The pollution index approached, but did not dip below, the threshold for minor impairment at Station 5. The number of diatom species increased by nearly 50% between Station 4 and Station 5, perhaps indicating an increase in nutrient concentrations below Elk Creek. Algae samples collected by University of Montana researchers in 1998 indicated minor organic loading below Elk Creek (Bahls 1999).

The siltation index indicated little or no siltation at all sites except at Station 5, where the siltation index exceeded the threshold for minor impairment (Table 5). Periphyton samples collected by University of Montana researchers in 1998 indicated moderate siltation below Elk Creek and near the mouth of the East Boulder River (Bahls 1999).

Similarity indexes between adjacent sites indicated that the upper three sites had very similar floras in 1998 (Table 5). There was less similarity between diatom assemblages at the three downstream sites in 1999. Diatom assemblages collected on the same day from adjacent riffles of the same stream usually share between 60% and 80% of their diatom floras (Bahls 1993). Lower percentages may be due to intervening tributaries or to discharges of pollution. Diatom assemblages collected at Station 3 in 1998 and 1999 had about half of their floras in common.

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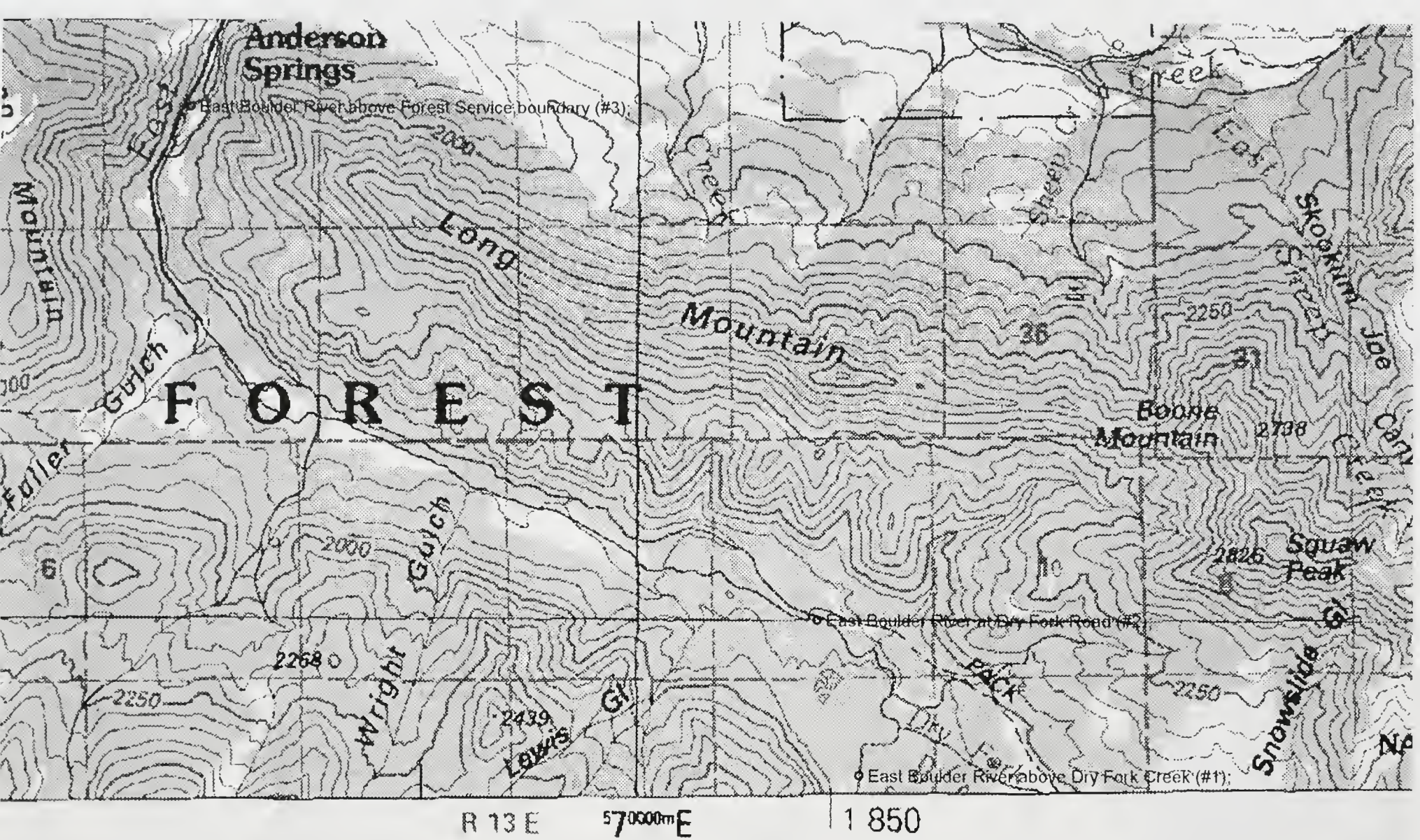

MAP 1.

Livingston 100K, MT; Scale 1" = 0.625Mi, 1.02[illegible] 2.25 [illegible] 1 Mi = 1.574" 1 [illegible] 23Mi

MAP 2.

'Livingston 100K; MT'; Scale, 1" = 0.625Mi, 1.022Mi, 3.254Ft, 1 Mi = 1.574", 1 cm = .402Mi

Table 1. Location of periphyton sampling stations on the East Boulder River, station code, sample number in the Montana Diatom Database, latitude/longitude, and sample date. Stations are listed in order from upstream to downstream.

Location	Station Code	Sample Number	Latitude/ Longitude	Sample Dates
East Boulder River above Dry Fork Creek	#1	0834-03	45 30 05 N 110 04 56 W	09/22/98
East Boulder River at Dry Fork Road Bridge	#2	0835-04	45 30 44 N 110 05 12 W	09/22/98
East Boulder River above Forest Service boundary	#3	1852-02 1852-01	46 01 56 N 111 02 38 W	09/22/98 08/13/99
East Boulder River above Elk Creek	#4	1853-01	45 35 07 N 110 06 36 W	08/13/99
East Boulder River at campground near mouth	#5	0836-04	45 37 20 N 110 07 39 W	08/13/99

Table 2. Diatom association metrics used to evaluate biological integrity in Montana streams: reference, range of values in Montana streams, and expected direction of metric response to increasing anthropogenic perturbation or natural stress.

Metric	Reference	Range of Values	Expected Response
Shannon Species Diversity	Bahls 1979	0.00-5.00+	Decrease[1]
Pollution Index[2]	Bahls 1993	1.00-3.00	Decrease
Siltation Index[3]	Bahls 1993	0.00-90.0+	Increase
Disturbance Index[4]	Barbour *et al.* 1999	0.00-100.0	Increase
No. Species Counted	Bahls 1979, 1993	0-100+	Decrease[1]
Percent Dominant Species	Barbour *et al.* 1999	5.0-100.0	Increase
Percent Abnormal Cells	McFarland *et al.* 1997	0.0-20.0+	Increase
Similarity Index	Whittaker 1952	0.0-80.0+	Decrease
Percent Epithemiaceae	Stevenson & Pan 1999	0.0-80.0+	Decrease
Percent Aerophiles	Johansen 1999	0.0-100	Increase

[1] Shannon diversity and species richness may increase somewhat in naturally nutrient-poor mountain streams in response to slight to moderate increases in nutrients or sediment.

[2] Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species.

[3] Sum of the percent abundances of all species in the genera *Navicula*, *Nitzschia*, and *Surirella*.

[4] Percent abundance of *Achnanthes minutissima*.

Table 3. Criteria for rating levels of biological integrity, environmental impairment or natural stress, and aquatic life use support in wadeable **mountain** streams of Montana using selected metrics for benthic diatom associations. The lowest rating for any one metric is the overall rating for the study site.

Biological Integrity/ Impairment or Natural Stress/Use Support	Diversity Index (Shannon)	Pollution Index	Siltation Index	Disturbance Index	Number of Species Counted	Percent Dominant Species	Percent Abnormal Cells	Similarity Index[1]
Excellent None/Full Support	>2.99	>2.50	<20.0	<25.0	>29	<25.0	0.0	>59.9
Good/Minor Full Support	2.00-2.99	2.01-2.50	20.0-39.9	25.0-49.9	20-29	25.0-49.9	>0.0-<1.0	40.0-59.9
Fair/Moderate Partial Support	1.00-1.99	1.50-2.00	40.0-59.9	50.0-74.9	10-19	50.0-74.9	1.0-9.9	20.0-39.9
Poor/Severe Nonsupport	<1.00	<1.50	>59.9	>74.9	<10	>74.9	>9.9	<20.0

[1] The Similarity Index or Percent Community Similarity (Whittaker 1952) may be used to compare a study site to an unimpaired upstream control site on the same stream. This metric measures the degree of floristic similarity between diatom associations at the two sites and is the sum of the smaller of the two percent abundance values for each species that is common to both sites. Adjacent riffles on the same stream, without intervening tributaries or environmental perturbations, will generally have at least 60% of their diatom floras in common (Bahls 1993). PCS may also be used to guage the relative amount of impairment or recovery that occurs between adjacent study sites: >59.9% = very similar floras, no change; 40.0-59.9% = somewhat similar floras, minor change; 20.0-39.9% = somewhat dissimilar floras, moderate change; <20.0% = very dissimilar floras, major change.

Table 4. Estimated relative abundance of algal cells and rank by biovolume of diatoms (Bacillariophyceae) and genera of non-diatom algae in periphyton samples collected from selected sites on the East Boulder River in 1998 and 1999: d = dominant, a = abundant, f = frequent, c = common, o = occasional, r = rare.

Taxa	Station/Date					
	#1 09/22/98	#2 09/22/98	#3 09/22/98	#3 08/13/99	#4 08/13/99	#5 08/13/99
Chlorophyta (green algae)						
Chaetophora			c(5)			
Closterium						c(3)
Stigeoclonium	c(4)		f(2)	c(5)		c(4)
Ulothrix	f(3)	f(4)		f(3)		
Chrysophya (golden algae)						
Bacillariophyceae	d(1)	f(3)	c(6)	c(4)	c(2)	a(2)
Rhodophyta (red algae)						
Audouinella		a(2)	r			
Cyanophyta (cyanobacteria)						
Calothrix		r				
Chamaesiphon		r	d(1)			
Oscillatoria	r	d(1)	c(4)			
Phormidium	d(2)	a(5)	a(3)	a(2)	a(1)	d(1)
Rivularia		c(6)				
Schizothrix				d(1)		
No. Non-diatom Genera	4	7	6	4	1	3

Table 5. Percent relative abundance of major diatom species[1] and values of selected diatom association metrics for periphyton samples collected from selected sites on the East Boulder River in 1998 and 1999. Underlined values indicate full support of aquatic life uses with minor impairment; **bold values** indicate partial support of aquatic life uses and moderate impairment; all other values indicate full support of aquatic life uses and no impairment.

Species/Metric (Pollution Tolerance Class)	Station/Date					
	#1 09/22/98	#2 09/22/98	#3 09/22/98	#3 08/13/99	#4 08/13/99	#5 08/13/99
Achnanthes biasolettiana (3)	10.05	7.07	6.00	1.88	5.01	0.23
Achnanthes minutissima (3)	70.33	61.99	46.67	23.00	29.12	7.46
Cocconeis placentula (3)	0.72	3.36	12.67	2.23	7.76	1.98
Cymbella silesiaca (2)	0.12	0.24	2.44	4.11	14.56	17.37
Cymbella turgidula (3)	0.00	0.00	0.00	0.47	4.65	21.68
Gomphonema micropus (2)	5.98	3.00	2.22	36.97	5.37	0.23
Number of Cells Counted	418	417	225	426	419	429
Number of Species Counted	**14**	27	24	29	31	44
Shannon Species Diversity	**1.68**	2.35	2.91	3.18	3.66	4.04
Percent Dominant Species	**70.00**	**61.99**	46.67	36.97	29.12	21.68
Disturbance Index	**70.00**	**61.99**	46.67	23.00	29.12	7.46
Pollution Index	2.89	2.93	2.90	2.48	2.61	2.52
Siltation Index	0.00	0.00	0.00	1.19	1.70	23.04
Percent Epithemiaceae	0.00	1.80	1.11	0.00	0.00	0.00
Similarity Index		76.38	72.40	45.96	52.36	51.93

[1] A major diatom species accounts for 10.0 percent or more of the diatom cells counted at one or more stations in a sample set.

APPENDIX A: DIATOM PROPORTIONAL COUNTS

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
083403	Achnanthes biasolettiana	3	84	10.05
083403	Achnanthes lanceolata	2	0	0.00
083403	Achnanthes minutissima	3	588	70.33
083403	Amphora pediculus	3	3	0.36
083403	Cocconeis placentula	3	6	0.72
083403	Cymbella affinis	3	25	2.99
083403	Cymbella falaisensis	3	0	0.00
083403	Cymbella minuta	2	19	2.27
083403	Cymbella silesiaca	2	1	0.12
083403	Cymbella turgidula	3	0	0.00
083403	Diatoma hiemale	3	0	0.00
083403	Diatoma mesodon	3	4	0.48
083403	Eunotia minor	2	0	0.00
083403	Fragilaria construens	3	0	0.00
083403	Fragilaria leptostauron	3	2	0.24
083403	Fragilaria pinnata	3	0	0.00
083403	Fragilaria vaucheriae	2	0	0.00
083403	Gomphonema micropus	2	50	5.98
083403	Gomphonema olivaceoides	3	2	0.24
083403	Gomphonema pumilum	3	2	0.24
083403	Hannaea arcus	3	24	2.87
083403	Nitzschia inconspicua	2	0	0.00
083403	Synedra acus	2	26	3.11

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
083504	Achnanthes biasolettiana	3	59	7.07
083504	Achnanthes exigua	3	0	0.00
083504	Achnanthes laevis	3	0	0.00
083504	Achnanthes minutissima	3	517	61.99
083504	Amphora inariensis	3	0	0.00
083504	Amphora pediculus	3	2	0.24
083504	Cocconeis placentula	3	28	3.36
083504	Cyclotella distinguenda	2	1	0.12
083504	Cymbella affinis	3	10	1.20
083504	Cymbella cistula	3	0	0.00
083504	Cymbella cymbiformis	3	0	0.00
083504	Cymbella descripta	3	0	0.00
083504	Cymbella hebridica	3	2	0.24
083504	Cymbella hustedtii	3	0	0.00
083504	Cymbella laevis	3	0	0.00
083504	Cymbella lapponica	3	0	0.00
083504	Cymbella microcephala	2	1	0.12
083504	Cymbella minuta	2	11	1.32
083504	Cymbella silesiaca	2	2	0.24
083504	Cymbella sinuata	3	0	0.00
083504	Cymbella turgidula	3	0	0.00
083504	Denticula tenuis	3	15	1.80
083504	Diatoma hiemale	3	0	0.00
083504	Diatoma mesodon	3	1	0.12
083504	Didymosphenia geminata	3	1	0.12
083504	Diploneis parma	3	0	0.00
083504	Fragilaria brevistriata	3	0	0.00
083504	Fragilaria construens	3	44	5.28
083504	Fragilaria leptostauron	3	4	0.48
083504	Fragilaria pinnata	3	18	2.16
083504	Fragilaria vaucheriae	2	10	1.20
083504	Gomphonema angustatum	3	1	0.12
083504	Gomphonema micropus	2	25	3.00
083504	Gomphonema minutum	3	4	0.48
083504	Gomphonema olivaceoides	3	41	4.92
083504	Gomphonema parvulum	1	0	0.00
083504	Gomphonema procerum	3	6	0.72
083504	Gomphonema pumilum	3	16	1.92
083504	Hannaea arcus	3	3	0.36
083504	Meridion circulare	3	0	0.00
083504	Navicula aquaedurae	2	0	0.00
083504	Navicula cryptotenella	2	0	0.00
083504	Navicula radiosa	3	0	0.00
083504	Neidium bisulcatum	3	0	0.00
083504	Nitzschia angustata	2	0	0.00
083504	Nitzschia inconspicua	2	0	0.00
083504	Nitzschia lacuum	3	0	0.00
083504	Nitzschia linearis	2	0	0.00
083504	Nitzschia pura	2	1	0.12
083504	Synedra tenera	2	0	0.00
083504	Synedra ulna	2	11	1.32

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
185202	Achnanthes biasolettiana	3	27	6.00
185202	Achnanthes clevei	3	0	0.00
185202	Achnanthes laevis	3	0	0.00
185202	Achnanthes lanceolata	2	7	1.56
185202	Achnanthes minutissima	3	210	46.67
185202	Amphora pediculus	3	1	0.22
185202	Cocconeis placentula	3	57	12.67
185202	Cymbella affinis	3	10	2.22
185202	Cymbella cymbiformis	3	2	0.44
185202	Cymbella hebridica	3	11	2.44
185202	Cymbella lapponica	3	1	0.22
185202	Cymbella leptoceros	3	0	0.00
185202	Cymbella minuta	2	1	0.22
185202	Cymbella silesiaca	2	11	2.44
185202	Cymbella sinuata	3	12	2.67
185202	Cymbella turgidula	3	0	0.00
185202	Denticula tenuis	3	5	1.11
185202	Diatoma hiemale	3	12	2.67
185202	Diatoma mesodon	3	4	0.89
185202	Fragilaria brevistriata	3	1	0.22
185202	Fragilaria construens	3	26	5.78
185202	Fragilaria leptostauron	3	0	0.00
185202	Fragilaria pinnata	3	8	1.78
185202	Fragilaria vaucheriae	2	12	2.67
185202	Gomphonema micropus	2	10	2.22
185202	Gomphonema olivaceoides	3	5	1.11
185202	Gomphonema parvulum	1	0	0.00
185202	Gomphonema procerum	3	0	0.00
185202	Gomphonema pumilum	3	7	1.56
185202	Hannaea arcus	3	1	0.22
185202	Meridion circulare	3	0	0.00
185202	Navicula cocconeiformis	3	0	0.00
185202	Navicula graciloides	2	0	0.00
185202	Navicula tripunctata	3	0	0.00
185202	Nitzschia linearis	2	0	0.00
185202	Synedra ulna	2	9	2.00

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
185201	Achnanthes biasolettiana	3	16	1.88
185201	Achnanthes laevis	3	4	0.47
185201	Achnanthes lanceolata	2	2	0.23
185201	Achnanthes minutissima	3	196	23.00
185201	Amphora inariensis	3	0	0.00
185201	Amphora pediculus	3	2	0.23
185201	Aulacoseira alpigena	3	0	0.00
185201	Caloneis bacillum	2	0	0.00
185201	Cocconeis pediculus	3	0	0.00
185201	Cocconeis placentula	3	19	2.23
185201	Cocconeis pseudothumensis	3	0	0.00
185201	Cymbella affinis	3	12	1.41
185201	Cymbella cistula	3	0	0.00
185201	Cymbella cymbiformis	3	0	0.00
185201	Cymbella hebridica	3	2	0.23
185201	Cymbella minuta	2	13	1.53
185201	Cymbella silesiaca	2	35	4.11
185201	Cymbella sinuata	3	4	0.47
185201	Cymbella turgidula	3	4	0.47
185201	Denticula tenuis	3	0	0.00
185201	Diatoma hiemale	3	26	3.05
185201	Diatoma mesodon	3	11	1.29
185201	Fragilaria construens	3	23	2.70
185201	Fragilaria leptostauron	3	2	0.23
185201	Fragilaria pinnata	3	6	0.70
185201	Fragilaria vaucheriae	2	6	0.70
185201	Gomphonema angustatum	2	0	0.00
185201	Gomphonema micropus	2	315	36.97
185201	Gomphonema minutum	3	2	0.23
185201	Gomphonema olivaceum	3	22	2.58
185201	Gomphonema parvulum	1	8	0.94
185201	Gomphonema procerum	3	6	0.70
185201	Gomphonema pumilum	3	16	1.88
185201	Hannaea arcus	3	35	4.11
185201	Meridion circulare	3	0	0.00
185201	Navicula cryptotenella	2	1	0.12
185201	Navicula ignota	2	0	0.00
185201	Navicula radiosa	3	0	0.00
185201	Navicula reichardtiana	2	0	0.00
185201	Navicula tripunctata	3	5	0.59
185201	Neidium bisulcatum	3	0	0.00
185201	Nitzschia angustata	2	0	0.00
185201	Nitzschia dissipata	3	0	0.00
185201	Nitzschia fonticola	3	6	0.70
185201	Nitzschia linearis	2	0	0.00
185201	Pinnularia microstauron	2	0	0.00
185201	Rhoicosphenia curvata	3	0	0.00
185201	Synedra ulna	2	53	6.22

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
185301	Achnanthes biasolettiana	3	42	5.01
185301	Achnanthes lanceolata	2	7	0.84
185301	Achnanthes minutissima	3	244	29.12
185301	Achnanthes pusilla	3	0	0.00
185301	Amphora pediculus	3	4	0.48
185301	Cocconeis placentula	3	65	7.76
185301	Cymbella affinis	3	19	2.27
185301	Cymbella cistula	3	0	0.00
185301	Cymbella laevis	3	0	0.00
185301	Cymbella mesiana	2	18	2.15
185301	Cymbella microcephala	2	7	0.84
185301	Cymbella minuta	2	11	1.31
185301	Cymbella silesiaca	2	122	14.56
185301	Cymbella sinuata	3	15	1.79
185301	Cymbella turgidula	3	39	4.65
185301	Denticula tenuis	3	0	0.00
185301	Diatoma mesodon	3	9	1.07
185301	Diatoma vulgaris	3	6	0.72
185301	Diploneis oblongella	3	0	0.00
185301	Fragilaria construens	3	12	1.43
185301	Fragilaria leptostauron	3	4	0.48
185301	Fragilaria pinnata	3	0	0.00
185301	Fragilaria vaucheriae	2	29	3.46
185301	Gomphonema clavatum	2	2	0.24
185301	Gomphonema micropus	2	45	5.37
185301	Gomphonema minutum	3	9	1.07
185301	Gomphonema olivaceum	3	12	1.43
185301	Gomphonema parvulum	1	6	0.72
185301	Gomphonema procerum	3	4	0.48
185301	Gomphonema pumilum	3	5	0.60
185301	Hannaea arcus	3	16	1.91
185301	Meridion circulare	3	1	0.12
185301	Navicula cryptotenella	2	1	0.12
185301	Navicula lanceolata	2	0	0.00
185301	Navicula radiosa	3	0	0.00
185301	Navicula reichardtiana	2	0	0.00
185301	Navicula tripunctata	3	10	1.19
185301	Nitzschia amphibia	2	0	0.00
185301	Nitzschia hantzschiana	3	2	0.24
185301	Nitzschia inconspicua	2	0	0.00
185301	Nitzschia palea	1	2	0.24
185301	Synedra parasitica	2	0	0.00
185301	Synedra ulna	2	70	8.35

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
083604	Achnanthes biasolettiana	3	2	0.23
083604	Achnanthes lanceolata	2	2	0.23
083604	Achnanthes minutissima	3	64	7.46
083604	Amphora pediculus	3	4	0.47
083604	Aulacoseira alpigena	3	0	0.00
083604	Caloneis bacillum	2	0	0.00
083604	Cocconeis pediculus	3	7	0.82
083604	Cocconeis placentula	3	17	1.98
083604	Cyclotella distinguenda	3	0	0.00
083604	Cymbella affinis	3	21	2.45
083604	Cymbella laevis	3	0	0.00
083604	Cymbella mesiana	2	22	2.56
083604	Cymbella microcephala	2	0	0.00
083604	Cymbella minuta	2	19	2.21
083604	Cymbella silesiaca	2	149	17.37
083604	Cymbella sinuata	3	16	1.86
083604	Cymbella turgidula	3	186	21.68
083604	Denticula tenuis	3	0	0.00
083604	Diatoma mesodon	3	2	0.23
083604	Diatoma vulgaris	3	32	3.73
083604	Diploneis oblongella	3	2	0.23
083604	Fragilaria brevistriata	3	0	0.00
083604	Fragilaria construens	3	0	0.00
083604	Fragilaria crotonensis	3	0	0.00
083604	Fragilaria leptostauron	3	2	0.23
083604	Fragilaria pinnata	3	6	0.70
083604	Fragilaria vaucheriae	2	26	3.03
083604	Gomphonema aquaemineralis	1	3	0.35
083604	Gomphonema micropus	2	2	0.23
083604	Gomphonema minutum	3	2	0.23
083604	Gomphonema olivaceum	3	5	0.58
083604	Gomphonema pumilum	3	2	0.23
083604	Hannaea arcus	3	4	0.47
083604	Melosira varians	2	0	0.00
083604	Navicula capitata	2	0	0.00
083604	Navicula capitatoradiata	2	9	1.05
083604	Navicula cryptotenella	2	3	0.35
083604	Navicula gregaria	2	2	0.23
083604	Navicula lanceolata	2	0	0.00
083604	Navicula libonensis	2	0	0.00
083604	Navicula lundii	2	0	0.00
083604	Navicula menisculus	2	3	0.35
083604	Navicula reichardtiana	2	42	4.90
083604	Navicula tripunctata	3	42	4.90
083604	Nitzschia acicularis	2	2	0.23
083604	Nitzschia alpina	3	2	0.23
083604	Nitzschia capitellata	2	0	0.00
083604	Nitzschia dissipata	3	26	3.03
083604	Nitzschia fonticola	3	2	0.23
083604	Nitzschia gracilis	2	0	0.00
083604	Nitzschia hantzschiana	3	5	0.58
083604	Nitzschia heufleriana	3	2	0.23
083604	Nitzschia linearis	2	15	1.75
083604	Nitzschia palea	1	5	0.58
083604	Nitzschia paleacea	2	30	3.50
083604	Nitzschia pura	2	0	0.00
083604	Nitzschia pusilla	1	0	0.00
083604	Nitzschia supralitorea	2	3	0.35
083604	Nitzschia vermicularis	2	1	0.12
083604	Rhoicosphenia curvata	3	0	0.00
083604	Surirella angusta	1	2	0.23
083604	Surirella minuta	2	5	0.58
083604	Synedra ulna	2	60	6.99